

Name: \_\_\_\_\_

Date: \_\_\_\_\_ Period: \_\_\_\_\_

## Flame Test Part I: Pre-Lab

**Introduction:** In this lab you will conduct a flame test of 3 unknown solutions. You will measure wavelengths of each sample and then use the speed of light equation to determine the unknown chemical. However, in order to complete this lab you will need to understand several mathematical equations and vocabulary. Before completing Parts 2-4, you MUST complete the pre-lab so you are able to complete this assignment correctly and on time.

**Vocabulary and Key Concepts:** Explain these big ideas in complete sentences.

1. What do *wavelength* and *frequency* measure? How are these two ideas mathematically related? *Wavelength measures the distance between two peaks in a wave while frequency measures the number of times a wave repeats itself per unit time. These two properties are related by the speed of light equation which says that  $c = \lambda\nu$ .*

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2. How can you find the energy of a wave? *Once wave frequency has been calculated, wave energy can then be determined using the wave energy formula,  $E = h\nu$ , where E is energy, h is Planck's constant and  $\nu$  is frequency.*

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3. What is a flame test? What does the *Law of Conservation of Energy* have to do with this type of experiment? *A flame test uses the concept of electron excitation to identify an element. By adding energy to a sample and observing the specific wavelength light that is produced, frequency and energy can be calculated. While the flame test relies on electron excitation to produce light, the light emitted is a direct result of the Law of Conservation of Energy which states that energy can not be created nor destroyed but can change forms. This applies to the flame test because as heat energy goes into the unknown solution, it is converted into light energy which is the observable measurement.*

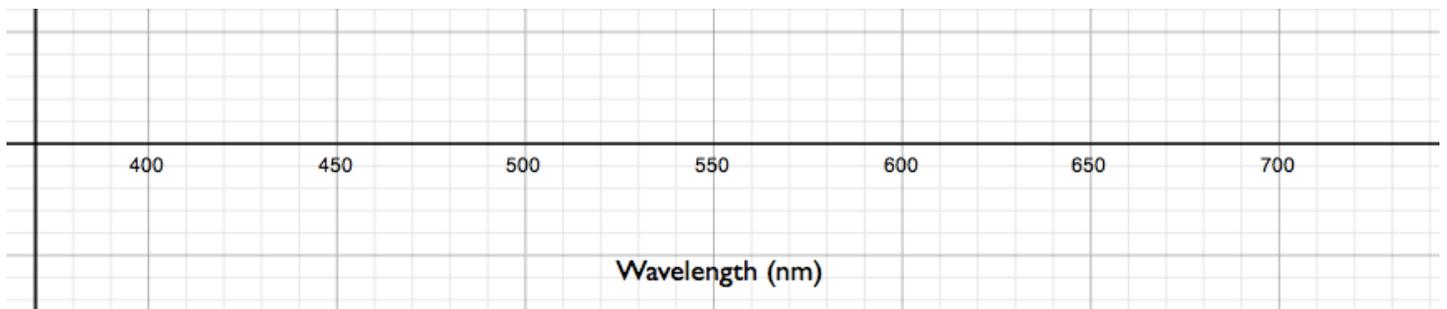
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**Electromagnetic Spectrum:** Use color pencils or markers to **shade** and **label** the complete visible spectrum.

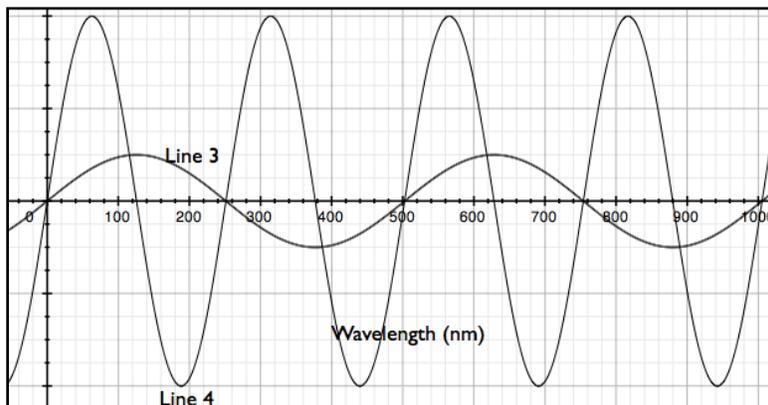
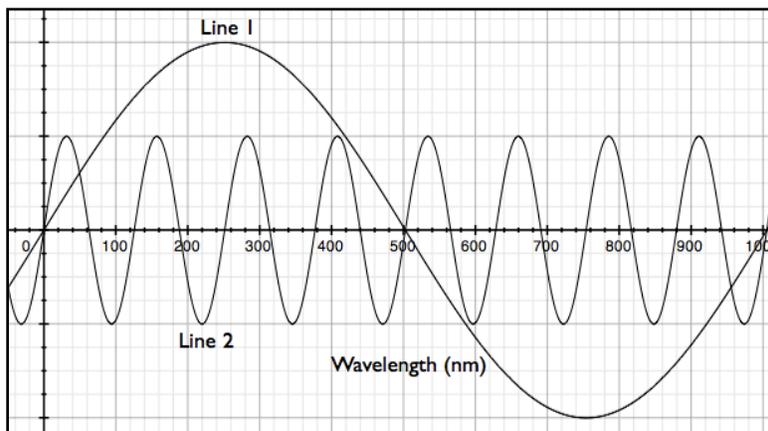


**Flame Test Basics:** Complete the table below showing the *Before*, *During* and *After* steps of a flame test.

	<b>Before Flame Test</b> Ground State Li Atom	<b>During Flame Test</b> Excited Li Atom	<b>After Flame Test</b> Ground State Li Atom
Draw the Bohr diagram for each step of the Flame Test			
What is happening to the electrons in the atom?	<i>Electrons occupy the lowest possible energy level</i>	<i>Valence electron absorbs energy and becomes excited to the next energy level</i>	<i>Excited valence electron returns to ground state and energy is released in the form of light</i>

**Wavelength and Frequency:** Find the wavelength and frequency of the four waves shown below.

	<b>Line 1</b>	<b>Line 2</b>	<b>Line 3</b>	<b>Line 4</b>
<b>Wavelength</b>	<i>1000 nm</i>	<i>125 nm</i>	<i>500 nm</i>	<i>250 nm</i>
<b>Frequency</b>	<i>1 s<sup>-1</sup></i>	<i>8 s<sup>-1</sup></i>	<i>2 s<sup>-1</sup></i>	<i>4 s<sup>-1</sup></i>



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## Flame Test Part 2: Data Collection

Flame Test Part 2 Objective: \_\_\_\_\_

### Materials:

- 3 Flame Test Solutions
- 3 100 mL Beakers
- 3 Watch Glasses
- 3 Matches
- Candle
- 10 mL Graduated Cylinder

### Experimental Procedure:

1. Put on safety goggles
2. Place watch glass on top of 100 mL beaker
3. Measure 5 mL of your first Flame Test Solution in graduated cylinder
4. Carefully pour 5 mL Flame Test Solution 1 into the watch glass
5. Light a match using the candle at your lab bench and CAREFULLY touch the edge of the Flame Test Solution in the watch glass
6. Observe the color of the flame and estimate the wavelength using the laminated Visible Light Spectrum Card
7. Write down the color and estimated wavelength in Data Table 1
8. Repeat steps 2-7 for the other two Flame Test Solutions using the remaining beakers and watch glasses
9. Let glass cool down while you work on the Wavelength Comparison questions
10. Clean up your station (put all materials neatly back into the bin and return Flame Test Solutions to the front counter)

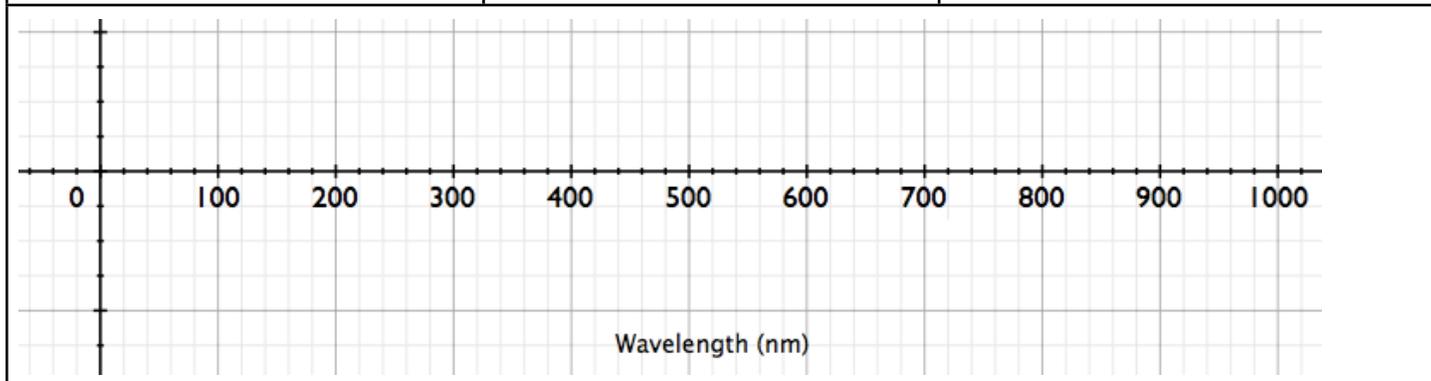
### Data Table 1:

Flame Test Solution #	Color Description	Estimated Wavelength (nm)
1	Pink	$\lambda = 650 \text{ nm}$
4	Green	$\lambda = 530 \text{ nm}$
6	Yellow	$\lambda = 600 \text{ nm}$

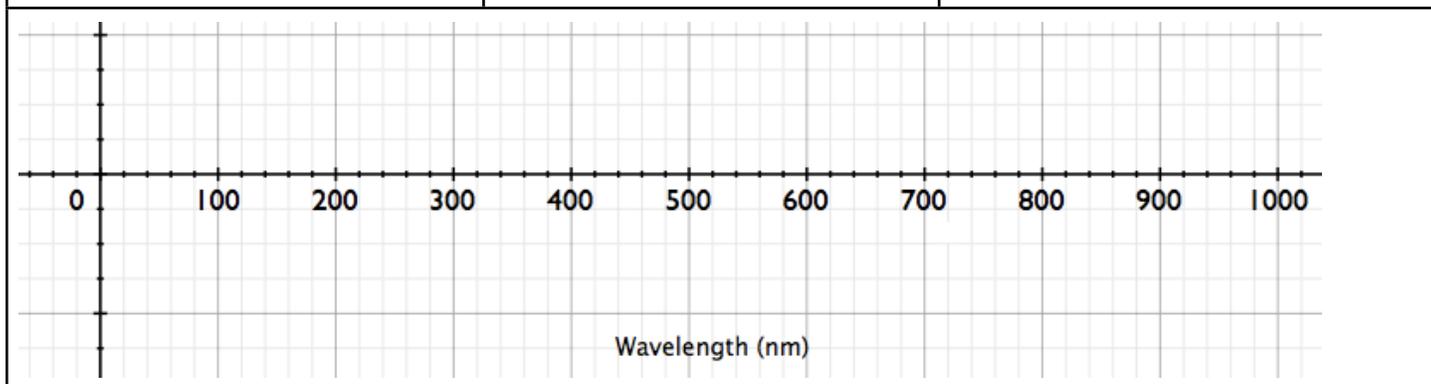
### Wavelength Comparison:

I. Draw each observed wavelength below.

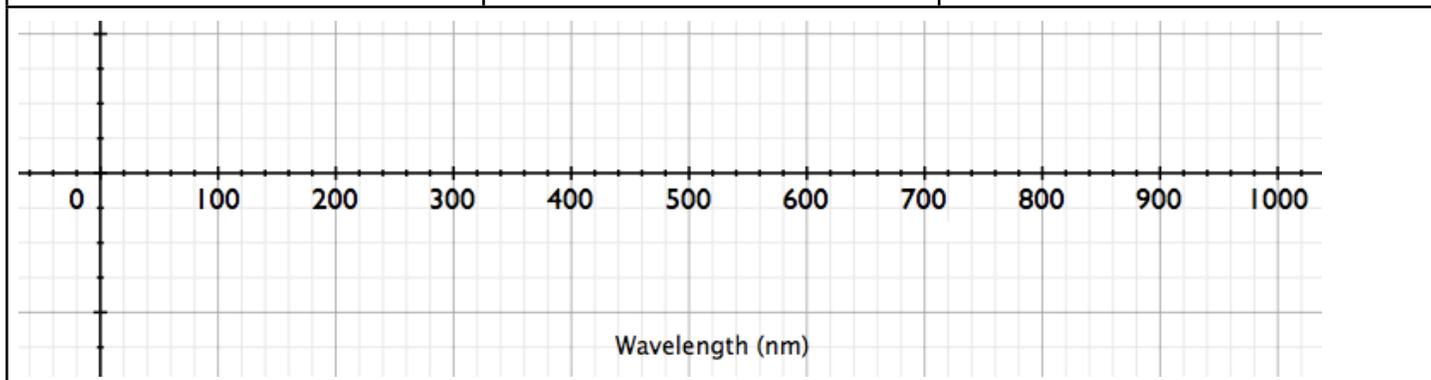
Flame Test Solution #	Color	Estimated Wavelength (nm)
1	Pink	$\lambda = 650 \text{ nm}$



Flame Test Solution #	Color	Estimated Wavelength (nm)
4	Green	$\lambda = 530 \text{ nm}$



Flame Test Solution #	Color	Estimated Wavelength (nm)
6	Yellow	$\lambda = 600 \text{ nm}$



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**Flame Test Part 3: Data Analysis****Flame Test Part 3 Objective:** \_\_\_\_\_**Frequency Equation:** Starting with the *Speed of Light Equation*, rearrange the equation to isolate frequency ( $\nu$ ). Then define each variable, including units.

Speed of Light Equation	Frequency Equation	Define Variables
$c = \nu\lambda$	$\nu = \frac{c}{\lambda}$	$\nu$ = Frequency ( $s^{-1}$ ) $c$ = Speed of Light (3000 nm/s) $\lambda$ = Wavelength (nm)

**Energy Equation:** Write the *Wave Energy Equation*, then define each variable, including units.

Wave Energy Equation	Define Variables
$E = h\nu$	$E$ = Energy (kJ/mol) $h$ = Planck's Constant (40 kJ/mol) $\nu$ = Frequency ( $s^{-1}$ )

**Calculations:** Use your wavelength data from Part 2 to solve for frequency and energy of each sample. Make sure to show ALL of your work.

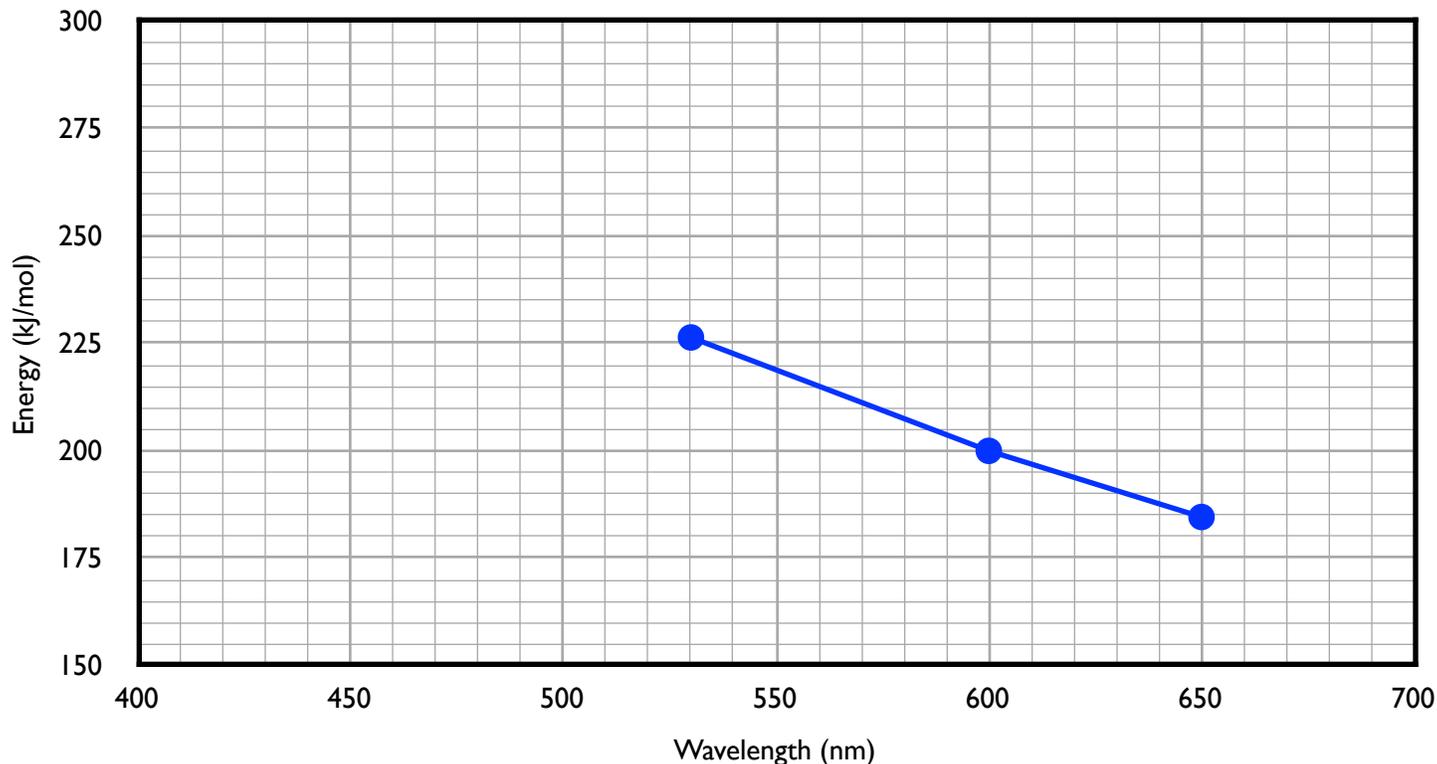
Flame Test Solution # <u>1</u>	Wavelength (nm) $\lambda = 650 \text{ nm}$
<b>Frequency Calculation</b>  $\nu = \frac{c}{\lambda} = \frac{3000}{650}$	<b>Wave Energy Calculation</b>  $E = h\nu$ $E = (4.61)(40)$
<b>Frequency = <math>\nu = 4.61 \text{ s}^{-1}</math></b>	<b>Wave Energy = <math>E = 184.6 \text{ kJ/mol}</math></b>

<b>Flame Test Solution # 4</b>	<b>Wavelength (nm)</b> $\lambda = 530 \text{ nm}$
<p data-bbox="331 218 633 252"><b>Frequency Calculation</b></p> $v = \frac{c}{\lambda} = \frac{3000}{480}$	<p data-bbox="1003 218 1341 252"><b>Wave Energy Calculation</b></p> $E = vh$ $E = (6.25)(40)$
<b>Frequency = <math>v = 6.25 \text{ s}^{-1}</math></b>	<b>Wave Energy = <math>E = 250.0 \text{ kJ/mol}</math></b>

<b>Flame Test Solution # 6</b>	<b>Wavelength (nm)</b> $\lambda = 600 \text{ nm}$
<p data-bbox="331 1083 633 1117"><b>Frequency Calculation</b></p> $v = \frac{c}{\lambda} = \frac{3000}{600}$	<p data-bbox="1003 1083 1341 1117"><b>Wave Energy Calculation</b></p> $E = vh$ $E = (5.0)(40)$
<b>Frequency = <math>v = 5.0 \text{ s}^{-1}</math></b>	<b>Wave Energy = <math>E = 200.0 \text{ kJ/mol}</math></b>

### Graph Analysis:

1. Graph Wavelength (nm) vs. Energy (kJ/mol).



2. What do you notice about the graph?

*The wavelength versus energy graph shows a decreasing linear relationship.*

3. What does this say about the electromagnetic spectrum? What end of the spectrum has high energy? Which end has low energy?

*This indicates that waves that have longer wavelengths have lower energies, while waves that have shorter wavelengths have higher energy.*

### Element Identification:

1. Determine the element is in sample by comparing your calculated energies to the known energy values given on the Visible Light Spectrum Card.

Flame Test Solution	Calculated Energy Values (kJ/mol)	Known Energy Values (kJ/mol)	Element
# <u>1</u>	184.6	181.2	Lithium
# <u>4</u>	226.4	228.6	Boron
# <u>6</u>	200.0	279.1	Sodium

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## Flame Test Part 4: Fireworks and Flaming Pickles

Flame Test Part 4 Objective: \_\_\_\_\_

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### Fireworks! Reading:

1. What is the difference between incandescence and luminescence? *Incandescent light is produced when a substance is heated until begins to glow. Luminescence is caused when energy is added to substance and light is emitted based on that element.*

\_\_\_\_\_

2. How do the atoms in a firework produce light? *Light in a firework is produced by electrons absorbing energy and luminescing. Electrons travel from the original ground state into an excited state and produce light.*

\_\_\_\_\_

**Flaming Pickles:** Watch the Flaming Pickles demonstration and answer the following questions?

1. How is the flaming pickle similar to a firework? *The glowing pickles are a modified flame test experiment where electrons are excited by energy which is then emitted as a colored light.*

\_\_\_\_\_

2. Unlike a firework, which has a double fuse system, where is the energy for the flaming pickles come from? *The pickle experiment uses electricity to excite the electrons.*

\_\_\_\_\_

3. What happens to the atoms when energy is added? *The valence electron becomes excited and jumps to the next orbital. However, the electron can not sustain this excited state so it falls back down and releases that energy in the form of light (Law of Conservation of Energy).*

\_\_\_\_\_

4. How can you use information you learned in the Flame Test Lab and Fireworks! reading to determine the type of chemical used in each pickle? *If you can determine the wavelength of light being emitted, then the chemical composition can be determined by calculating the frequency and wave energy.*

\_\_\_\_\_

\_\_\_\_\_

**Firework Design:** Design your own firework, including the shape, color, chemicals needed and the calculated frequency and energy of each.

1. Describe your firework using at **two** colors. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. Determine what chemicals you will need to make your firework. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

3. What wavelength will these chemical produce? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. Calculate the frequency and energy each chemical will produce

<b>Chemical 1:</b> _____	
<b>Frequency Calculation</b>	<b>Wave Energy Calculation</b>

<b>Chemical 2:</b> _____	
<b>Frequency Calculation</b>	<b>Wave Energy Calculation</b>